Assessing the Development of Personal and Professional Skills in Group Projects

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ABSTRACT

Personal and professional skills developed during Design-Build-Test (DBT) group projects, such as team working and leadership, are difficult to assess using traditional methods such as technical reports. Academic staff often are not able to dedicate sufficient time to become embedded in the multiple projects they are typically supervising, in addition to other duties. As a result they do not have the required level of observation and discussion with the students to effectively assess these skills. This paper discusses methods and tools used to accurately and efficiently measure learning outcomes relevant to these personal and professional skills and comments on their effectiveness.

KEYWORDS

personal and professional skills, group projects, assessment.

INTRODUCTION

The type of major group DBT projects carried out by 3rd year Product Design and Development (PDD) and 4th year Mechanical Engineering undergraduate students at Queen's University Belfast is of a similar nature to the "capstone" projects carried out at many universities around the world. These generally seek to provide an authentic learning experience for students by including many elements which the students will face in professional practice, post graduation. The learning outcomes are broad and usually set at a high level of cognitive ability. In terms of taxonomy such as that described by Bloom [1] the objective is to test the highest level of intellectual ability which involves evaluation and synthesis of a problem through to a viable solution. As well as applying technical knowledge and understanding the students are expected to develop a range of personal and professional skills. These may include how to plan and manage tasks in a timely manner, how to work effectively as a leader or member of a team, how to communicate effectively with team members and faculty supervisors and how to resolve conflicts.

The requirement for these professional skills in addition to technical knowledge is recognised by a growing number of accreditation bodies such as the Institution of Mechanical Engineers (IMechE) who in the UK base their assessment on the Engineering Council's UK-SPEC document [2]. This specifies a standard for professional engineering competence including 2 sections (C and D) which relate specifically to "technical and commercial leadership" and "effective interpersonal skills". Similarly the international CDIO initiative has identified this requirement. A series of stakeholder surveys undertaken by a number of the collaborating universities highlighted that these personal and professional skills are highly valued by

employers and recognised by alumni as being every bit as important as technical knowledge in professional practice. Consequently the Syllabus developed by CDIO contains sections which deal with these requirements namely; Section 2 on Personal and Professional Skills and Attributes and Section 3 on Interpersonal Skills: Teamwork and Communication [3].
CDIO Standard 5 specifically states that degree programmes should have an introductory course that incorporates DBT experiences followed by at least one further DBT exercise of a more advanced and demanding nature, usually the capstone project. This rationale has been extended on the PDD programme to include an additional half module (5 ECTS points) group project in first year and a full module (10 ECTS points) with 3 group DBT exercises in 2nd year.
This staged progression during each year provides increased opportunities for the application of technical knowledge and for the development of personal and professional skills and attributes as suggested by Armstrong and Niewoehner [4].
The psychologist Csikszentmihalyi [5] describes flow as a state of consciousness in which people are more engaged with and get greater satisfaction from the activities in which they are involved. In an educational context this relates to deep learning rather than surface learning and assists the individual in their ability to progress through the stages of cognitive development. Csikszentmihalyi also contends that this state can be controlled by ordering the information that enters the consciousness. Often referred to as the "+1 principle", this requires setting tasks of appropriate level, challenging but achievable and related to prior knowledge and skill levels. Often described as being between boredom, where no new learning occurs, and panic where survival strategies rather than deep learning dominate.
In the case of the DBT projects Bloom's taxonomy of learning domains [1] is used to set appropriate progression of the learning outcomes for each year of the degree program [6]. Hence the students are able to build on their previous experiences of shorter group projects in the earlier years before being asked to tackle the capstone DBT project. This approach is aligned with the constructivism theory work of Vygotsky [7] and the experiential learning cycle model of Kolb [8] and means that graduating students are being better prepared for professional practice by the repeated opportunities to improve their personal and professional skills in the context of their application to multiple DBT projects.

Capstone Project Learning Outcomes

Stage 3 PDD and Stage 4 Mechanical Engineering students undertake a major (capstone) group project which accounts for 1/3 (20 ECTS points) or 1/4 (15 ECTS points) of their academic programme in the respective years. The learning outcomes are similar in both cases and can be summarised as follows:
To provide students with experience of working within a team on a realistic major project developing a product from the identification of a problem / customer need through concept development, product design specification, detailed design, prototyping, testing and finally to a plan for manufacture.
After successfully completing the project students are expected to be able to:

1. Apply knowledge and understanding of a specialist subject and related elements of professional product design practice.
2. Collate information, analyse and solve a technical problem.
3. Design or develop a system, component or process and recognise opportunities for improvements in a design.
4. Utilise appropriate laboratory equipment, computer software and instrumentation, in order to accomplish the objectives of a project.
5. Communicate effectively the results of a project in oral presentations and written reports.

6. Design and plan a project and manage the time involved to complete all tasks to the respective deadlines.
7. Work and learn independently and as a member of a project team.
8. Work and communicate effectively as a member of a project team.

The teams, of typically between 4 and 6 students, produce a number of deliverables during the 24 weeks of the project such as technical reports, working prototypes and oral presentations. These provide content which can be graded in relation to the product rather than the process and the collective output of the team rather than the individual. As such they can be used effectively in the assessment of learning outcomes 1 thru 5 (above) but not for items 6 thru 8 which relate to the personal and professional skills and attributes.
Biggs [9] states the importance of appropriate teaching and learning activities being provided and that assessment methods should be constructively aligned with these. It follows, therefore, that if learning outcomes related to personal and professional skills are defined within such projects that these should necessarily have appropriate opportunities for the students to develop the skills and have assessment methods which effectively measure these learning outcomes.
The remainder of this paper will detail how these learning outcomes (6 thru 8) are assessed in the 3rd year group projects on the PDD degree.

ASSESSMENT

It should be noted that while conflict resolution is a desirable skill it is not included in the learning outcomes. A conscious decision was made to avoid conflict where possible rather than engineer artificial scenarios. It is assumed that in any project there will be sufficient disagreement within the group that some experience of dealing with conflict will be gained. With this in mind the groups are constructed by the module coordinator with the objective of being balanced and harmonious.

Avoiding Dysfunctional Groups and Associated Impacts on Assessment

In order that all students work in an environment which is conducive to learning some effort has been put into the formation of the groups for the capstone project. By the end of 2nd year the students will have worked on 7 DBT projects of between 3 and 12 weeks duration. In all these cases the groups will have been constructed by the tutor with the objective of creating teams of balanced ability and learning style preferences. At the end of 2nd year the students (typically 30 in a PDD cohort) should have worked with all members of their year on at least 1 project. At this stage they are asked to confidentially rank all the students in their cohort in terms of their preference as a partner for the capstone project in stage 3. The top students in terms of academic performance (in the 7 previous DBT projects) are seeded into the various groups and they get to work with their first preference choice, or highest preference not currently assigned to another group. The 2nd student in each group then gets their highest preference still available and so on. In general the students have tended to produce a preference rank which correlates reasonably well with the performance ranking but significantly there are a few notable exceptions each year. Some very able students are not seen by their peers as being desirable partners for group work while others of lesser ability are considered highly desirable as team members. These individuals are the ones whose data points lie furthest from the best fit line of the graph in figure 1. The general correlation between performance and preference suggests that students are very aware of each other's ability and close friendships seldom override a desire to have an effective project partner.

With reference to Figure 1, the student who ranks 9th in performance and 1st in preference is clearly viewed as a good team player while the student ranked 5th in performance and only 15th in preference is perceived as being less preferable as a teammate.

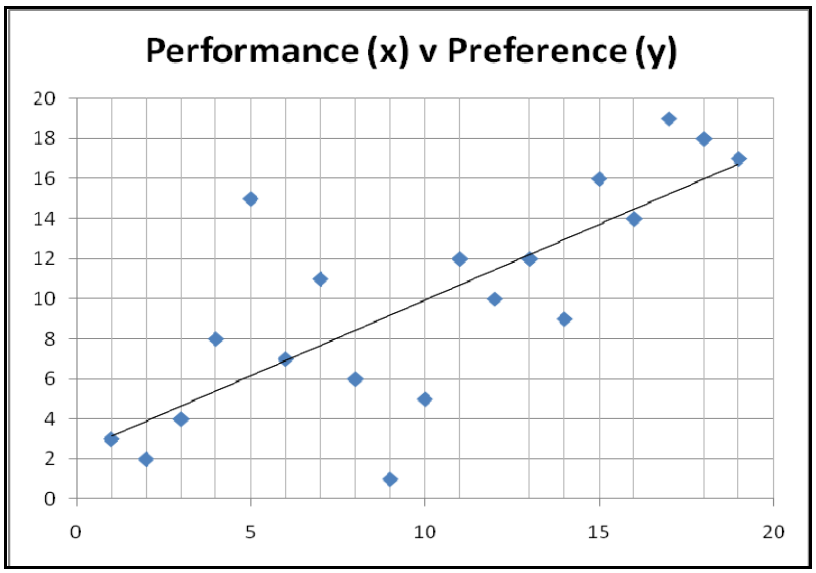

Figure 1 – Year 2 PDD performance versus peer preference rankings

This information can then be used in discussions with individuals as part of a Personal Development Planning (PDP) process either with the module coordinator, project supervisor or personal tutor. The same data also indicates which students individuals absolutely do not want to work with, as they will rank them last in their preferences. Hence individuals who are likely to fail to work effectively together can be kept apart. In Figure 2 each column represents an individual student's preference ranking by each of their peers. Some students are universally "popular" as project partners while others can rank highly with some of their peers but poorly with others. Weaker students tend to receive low rankings from all others in the year group.

Average		Rank	18	19	5	12	14	4	3	15	8	6	11	1	17	9	12	7	10	16	2		performance	preference
46.1		18		18	2	7	12	16	6	13	3	11	4	8	17	9	1	14	15	10	5		18	18
47.8		17	18		2	13	14	1	5	17	15	6	12	16	11	10	9	4	8	7	3		17	19
57.6		10	11	18		1	8	7	6	3	2	12	13	4	16	14	9	10	15	15	5		10	5
55.8		11	14	18	1		7	2	13	9	6	8	17	5	15	11	16	10	3	12	4		11	12
49.7		16	15	18	8	7		6	5	17	11	4	10	2	14	9	13	3	12	16	1		16	14
64.6		3	14	15	10	11	12		7	17	16	1	9	4	18	2	8	6	3	13	5		3	4
73.9		1	14	17	9	15	13	4		11	3	1	16	2	18	8	10	7	6	12	5		1	3
61.0		5	16	18	3	6	14	12	1		5	4	9	2	8	15	17	7	11	13	10		5	15
64.0		4	18	16	2	12	11	10	1	15		6	9	3	17	5	8	4	13	7	14		4	8
59.3		8	17	13	10	11	12	1	6	15	14		8	3	18	2	9	7	4	16	5		8	6
59.5		7	14	17	7	13	15	6	3	12	1	11		2	16	10	9	5	8	18	4		7	11
59.2		9	16	18	8	15	14	2	3	10	5	4	13		11	6	12	9	7	17	1		9	1
45.0		19	18	16	13	5	6	15	7	2	14	8	1	9		12	3	11	10	17	4		19	17
52.2		14	16	18	4	9	17	1	10	15	6	7	8	5	13		12	2	11	14	3		14	9
53.0		13	17	18	12	16	15	7	11	14	3	1	6	5	8	9		4	13	10	2		13	12
60.5		6	13	18	10	11	12	2	3	14	7	6	5	4	16	9	15		8	17	1		6	7
53.9		12	17	18	4	11	10	1	8	13	12	5	9	2	15	6	14	7		16	3		12	10
50.7		15	18	6	2	9	10	11	1	17	3	14	12	7	16	8	4	5	13		15		15	16
64.8		2	16	18	3	11	13	2	5	10	9	4	12	1	17	6	14	7	8	15			2	2
			15.7	16.6	6.1	10.2	11.9	5.9	5.6	12.4	7.5	6.3	9.6	4.7	14.7	8.4	10.2	6.8	9.3	13.6	5.0	Ave		
			2.0	3.0	4.0	3.9	2.9	5.0	3.4	4.4	5.0	3.8	4.1	3.6	3.2	3.5	4.4	3.1	3.8	3.4	4.0	SD		

Figure 2 – Year 2 PDD peer preference rankings

In addition to reducing the potential of having dysfunctional groups by keeping students with a mutual "dislike" apart the quality and accuracy of the data collected by peer assessment during the project should also be improved. Personality clashes are less likely to skew the objectivity of such assessments if groups can be constructed in this way. It could be argued that by allowing students to self select their groups that these would produce a similar environment. This approach doesn't however either challenge students in adapting to new partners or mimic the real world of work where self selection is uncommon.

What is significant here is that this preference ranking data tends to indicate something of the group dynamic within the cohort which is not easily observed by the academic staff. The students spend longer working with each other on these projects than it is possible for the faculty members to spend with each student and they are constantly making decisions and judgements about their peers in relation to how effective they are in their roles.

The idea that the students form accurate assessments of their peers that can be useful in helping faculty assess personal and professional skills has also been used in other areas of the assessment of these DBT projects.

Peer Assessment

Peer Assessment spreadsheets are used in all group projects in all years of study and are a mandatory requirement. The confidential peer assessment works on a zero mean basis with each student scoring themselves and all other members of the group in each of fifteen categories, which are aligned with the deliverables and learning outcomes of the particular project. 3 main areas are covered; technical contribution, contribution to deliverables and collaboration. Each row must add to zero and justifying comments must be entered for any rows with a non-zero value in any cell. These comments provide useful evidence to support the supervisor's observations of the group and the structured format ensures that each student comments on the same aspects of the project, which enables direct comparison across the group and ensures accuracy and consistency.

Guideline statements are provided defining the meaning of numbers in a range from -2.0 to +2.0 which students can enter in each cell. Five of the fifteen categories relate specifically to personal and professional skills, e.g.:

- Effectively takes charge of tasks assigned
- Is fair and even in the treatment of other group members
- Produces work on time
- Willing to take on tasks
- Communicates clearly with other members of the team

In the capstone project students are required to complete a peer assessment at the end of the first semester, which is half way through the project. At the start of the second semester all students have an individual interview with their project supervisor(s) which includes a discussion of the collated peer assessments for each group. Student's comments remain confidential but a summary of the scores is fed back to each student as the basis of a discussion of their own performance and to provide a focus for areas which could be improved. This practice has proved particularly beneficial to the students and has been warmly received by them as positive and constructive feedback, evidenced by module review comments. The timing of the feedback provides the student with an opportunity to take corrective action and for the supervisors to focus the attention of their observations over the 2nd semester on areas identified by the other students as being relatively weak. The students then complete a similar peer assessment at the

end of the project which provides an opportunity to assess any improvement as observed by the other student members of the group. It is important that the benefit of the peer assessment is sold to the students from the start of the project so that honest and valuable information is gathered for the interim feedback interviews. The use of the same format of peer assessment in previous years has built a familiarity with the method which helps ensure the quality of data returned.

Online Collaboration Tools

Since 2008 online collaboration has been facilitated by setting up private forums using Google Groups. This free web based utility is a refinement of Usenet discussion groups which have been in use for many years. The module coordinator creates a new group and restricts membership by invitation only to the students and supervisors of the project. This provides the groups of students with a shared space to upload files and a discussion forum to share information about relevant resources, reports and journal articles as well as somewhere to coordinate the scheduling of tasks in their project plans. The students are automatically sent an email when new content is added and the supervisors can upload resources, read and contribute to the discussion threads as well as provide instant feedback by rating each post on a 1 to 5 star basis. The resource can be accessed anytime and from anywhere with internet access and complements the required face to face project review meetings which the students organise and run with their supervisors. The students are made aware from the outset that their contribution is graded on a weekly basis as a measure of their level of engagement in the project and of their level of professional practice. By signing up to receive digest emails the supervisors conveniently receive a transcript of all activity in the group which can be kept as a record.
Quality as well as quantity of contribution are both measured with guidelines provided on the scoring metric used by the supervisors. The highest marks are reserved for contributions which clearly demonstrate a responsibility for moving the project forward. Posts giving only a description of work done by an individual of their assigned tasks receive a pass level grade. 3rd year students are expected to make at least 4 contributions to the online forum per week.
Fundamentally this facility enables the supervisors to obtain a view of how the group is operating. It can be used to ascertain who in the group is driving things forward, who can effectively communicate what they are doing and who can produce a concise summary of relevant technical information. The fact that it is ongoing for the full duration of the project removes the risk of being inaccurate by attempting to assess such skills as a snapshot during face to face meetings. The transcript produced from the digest emails enables an audit to be done in the event of a query or appeal by a student. It has however been noted that some students are more comfortable in either the online or the face to face meeting situation. The virtual environment is therefore not seen as replacing the formal design review meeting. Indeed it is desirable to include both as this provides additional opportunities for students to express themselves in a medium which is preferable to them. At the end of the project the supervisor provides a grade and a short report on each student based on a combination of their online and face to face interactions. It is noted that different skill sets are required in the virtual and real worlds and that quite often students need guidance in the appropriate use of both media. Again the interim interview provides an opportunity to discuss with each student their relative competence in these different skill sets and the requirement for both.

Leadership Skills

Not all students volunteer to take a leadership role in these projects. To provide each student with an experience of what it is like to lead the group they are forced to rotate the role at regular periods during the first 12 weeks. The leader acts as chair of the review meetings and is

responsible for the agenda and minutes as well as assigning tasks and deadlines. The supervisor attends the meetings rating all students' professional conduct and additionally assessing the leadership skills of the current holder of the post. In the second half of the project the groups elect their leader every 4 weeks by secret ballot in which they rank all members. This again uses the students' direct experience to provide additional input into the supervisor's assessment of leadership qualities. The mandatory requirement to act as leader for at least part of the project, while contrived, has received favourable comment in the module review, particularly from those students who would not volunteer to lead otherwise.

Reflective Critiques

In order to assess if students have developed the required skills and not just become aware of what is required in theory they are asked to write an individual reflective critique at the end of the project. This includes a section asking them to reflect on any skills and attributes they have developed during the course of the project which relate directly to the process of team working; specifically the 5 categories in the collaboration section of the peer assessment spreadsheet. The act of reflection on these specific learning outcomes and the requirement to articulate what has been learned both reinforces the learning and provides an additional submission which can be used in the assessment of these skills.

EFFICIENCY, ACCURACY & RELIABILITY

Efficiency

Assessing personal and professional skills requires observation and interaction with students over a period of time. While the cohort size described is relatively small (average of 30) it does still require a considerable amount of time to operate the regime described above. The interim feedback interviews of around 20 minutes are seen as particularly important and have been run with 2 supervisors present at each interview to date. This has been done to develop a consistency of delivery but the intention is that these can be done on a one to one basis in future. If however the faculty involved in supervision change the recommendation would be that any "new" faculty member should partner with an experienced supervisor for at least one year before operating alone.

The amount of information and discussion threads generated on Google Groups can be overwhelming, particularly at the start of the project when the groups are searching to find a customer need on which to theme their project. While this has proved a very valuable resource for all supervisors it is sensible that only 1 faculty member grades the posts, which requires more time and rigour. To facilitate this a precise marking rubric is essential to ensure consistency across groups. Supervisors record grades against each of the 3 main sections of the peer assessment spreadsheets (technical contributions, contribution to deliverables, collaboration) so that more detailed formative feedback can be provided and to identify students that are contributing in all the required areas of the project, and hence meeting all the intended learning outcomes. Markers are provided with preformatted electronic spreadsheet files in which to record their grades, which makes the collation of results relatively straight forward and standardised.

Accuracy

In order to encourage students to provide accurate information to guide the supervisors' assessments it is important to have a fair and accurate marking scheme. This has been

reinforced by an awareness of the adjustments made to individual scores about the group mean in the proceeding 7 DBT projects. By year 3 students know that freeloaders fail modules and that process as well as product is rewarded in the marking scheme. At the interim interviews students are given an indication of what grade they are heading for in the project and the reasons for their grade. At this point 30% of the marks will have been assigned so there is still much to be gained by the student responding to the feedback and guidance provided. To date this has had a very positive effect on a number of students who have managed to improve their overall grade significantly following this intervention. It is therefore suggested that the grades obtained are more accurate than a model which has only summative assessment and no interim feedback.

Reliability

In stage 4 of the PDD programme there exists an optional 12 week work placement project (30 ECTS points) which requires a major project to be undertaken. This provides an opportunity for employers to provide feedback on the level of personal and professional skills displayed by the placement students. To date only 4 students have completed such placements (with a further 7 due to complete in June 2010) and so statistics gathered are as yet insignificant. The intention is to continue a longitudinal study which asks the placement employers to grade and comment on the relevant skills, again in line with the relevant learning outcomes. To date the responses have been very favourable but it is anticipated that there will be scope for further refinement and improvement. This real life measurement is seen as having an important input into the continual development and refinement of these DBT projects and the development of the assessment of the associated personal and professional skills.

CONCLUSIONS

The development of personal and professional skills can be facilitated by providing numerous group DBT project experiences throughout all years of an undergraduate engineering programme, with staged progression defined by appropriate learning outcomes.

Students can provide valuable information which can be used as supporting evidence in the assessment of these skills through appropriate use of peer assessment and peer ranking.

Online tools such as Google Groups can be used to gather relevant input and data regarding the quality and quantity of contributions made by individuals when not in direct contact with project supervisors.

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